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TECHNOLOGY AND OVERALL PERFORMANCE OF INDONESIAN MANUFACTURING FIRMS:
Do Manufacturing Strategies Serve as Moderators

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Abstract

Although there have been many studies focusing on the determinants of technological adoption and innovation, there is still a dearth of empirical results that relate to technology adoption and performance, especially in the Indonesian manufacturing sector. Based on the fact that the increased use of advanced manufacturing technologies and new management practices cannot be directly related to higher performance, this study tries to integrate technological and innovation considerations with manufacturing strategic development. This study focuses on the role of manufacturing strategy in moderating the impact of hard and soft technology on overall performance. The alignment between technology and manufacturing strategy is necessary to ensure success of firms. Data were collected through mailed questionnaires to CEOs of medium and large manufacturing firms in Indonesia. This study finds that both hard and soft technologies have positive impacts on overall firm's performance. Further, manufacturing strategy plays an important moderating role on the relationship between technology and performance.

Keywords: Hard and soft technology, Manufacturing strategy and firm's performance

Introduction

Although there have been many studies focusing on the determinants of technological adoption and innovation, there is still a dearth of empirical results that relate to technology adoption and performance, especially in the Indonesian manufacturing sector. There is an abundance of literature that has analyzed the relationship between technology adoption and performance (Porter, 1985; Morone, 1989; Higgins, 1995; Hottenstein & Dean, 1995). Maidique and Patch (1988) argue that technology is a critical force for a business organization in a competitive environment. Morone (1989) views technology as a source of competitive advantage. While Stacey and Aston (1990) argue that technology advancement plays a vital role in long-term profitability, and Higgins, (1995) identifies technology as a contributing factor to successful operations.

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The theory that can explain why technology adoption improves organizational performance and creates competitive advantage can be attributed to Barney (1991) and early researchers who argue for the resource-based theory of competitive advantage. The theory holds that the firm's resources are key determinants of performance and competitive advantage. Firms can develop this competitive advantage only by creating value in a way that is difficult for a competitor to imitate. In this context, hard technology is considered as a resource. On the other hand, soft technology (organizational practices) reflects capabilities of the firms, which can be used as the basis for competitive advantage.

Prior studies on technology adoption found that the increased use of advanced manufacturing technologies (AMT) and new management practices cannot be directly related to higher performance (Sweene, 1991; Kotha & Orne, 1989; Schroeder, et al., 1995). Significant benefits can be reaped by the firms that integrate technology and innovations considerations with strategic corporate development (Shariff, 1997). Scholars have argued that strategy must be viewed as a major moderating variable and the success of business organizations depends on the ability of new technologies to support the competitive strategy.

This study was motivated by the following considerations: (1). The dearth of knowledge and empirical research concerning technology adoption by Indonesian manufacturing firms. (2). The lack of research that investigates the moderating effect of manufacturing strategy on the relationship between technology and performance. Other than focusing on the moderating role of strategy on the technology-performance relationship, this study investigates the impact of the level of technological adoption on performance in the Indonesian manufacturing sectors.

Literature Review

Technology and Competitive Advantage

The basic approach to define technology is to derive the concept from classical Greek. In classical Greek, the word 'technology' is the combination of 'techne' and 'logos'. The word 'techne' is interpreted as skill of hand or technique. The word 'logos' is interpreted as knowledge or science of skills or techniques (Autiou & Leimanen, 1995). Zeleny (1986) highlights that technology consists of three interdependent, codetermining, and equally important components: (1) hardware, which is the physical structure and logical layout of the equipment or machinery, used to carry out the required task; (2) software, which is the knowledge of how to use the hardware in order to carry out the required tasks; and (3) brainware, which is the reason for using the technology in a particular way (this may be referred to as *know-why*). In addition to these three, a fourth component must be considered interdependently for it encompasses all levels of technological achievement namely *know-how* (Khalil, 2000). Know-how

is the learned knowledge or acquired knowledge of technical skill regarding how to do a thing well. This may be the result of experience, transfer of knowledge or hands-on practices.

The distinction between technological and scientific knowledge is that scientific knowledge can be articulated or verbalized, whereas, technological knowledge nearly always comprises of tacit component. Technological knowledge is seldom completely expressed in exact norms and theories (Autio, 1991). Furthermore, Autio asserts that technology comprises of a strong knowledge component, which can be viewed as social, so that the technological knowledge component can be transferred through social interactions. This aspect makes it necessary to combine the component approach and the social approach in defining technology. Therefore, technology can be defined as the ability to recognize technical problems, the concept and the tangible things (machines and equipment), which are developed to solve technical problems. On the other hand, technology is hardware and software employed to solve operational problems effectively in an organization (Autio & Leimanen, 1995).

The fact that technology is a potential source of competitive advantage is widely accepted in management and economic literature. Technological adoption and technological innovation are powerful forces for industrialization, increasing productivity, supporting growth and improving the standard of living (Abernathy & Clark, 1985). Technological strength has affected manufacturing cost and other competitive drivers (Harrison & Samson, 1997). Schroeder (1990) found that technology adoption creates competitive opportunities and threats for those who adopted them and for those who did not. To develop a competitive advantage, organization need to choose, design, and implement manufacturing technologies that are consistent with the needs of competitive advantage (Hottenstein & Dean, 1995).

Technology – Manufacturing Strategy Relationship

Manufacturing strategy is viewed as the effective use of manufacturing strengths as a competitive weapon for the achievement of business and corporate goals (Swamidass and Newell, 1987). In addition, manufacturing strategy reflects the goal and strategy of business and enables the manufacturing function to contribute to the long-term competitiveness and performance of the business (Wheelwright and Hayes, 1985). Of late, manufacturing strategies adopted by manufacturing enterprises include low cost strategy, quality strategy, flexibility strategy and dependability strategy. Many researchers refer to a manufacturing strategy as a competitive priority (Burgess et al., 1998). Stonebaker and Leong (1994) define a cost strategy as the production and distribution of a product with minimum expenses and wasted resources. Quality strategy focuses on the need to manufacture products and services that conform to the specifications and customer needs (Braglia, et al., 2000). Flexibility strategy is the ability to responds to the rapid changes of the products, services and processes. This

strategy is often identified as mix or volume flexibility. Leong, et al. (1989) define delivery strategy as dependability of delivery (by meeting delivery schedule or promises) and speed of delivery (react quickly to customer order).

The literature on the link between technology and manufacturing strategy has been in existence for a long time (Skinner, 1974; Buffa, 1984; Burgess, et al., 1998; Cagliano & Spigna, 2000). Skinner (1974) advocates a wide variety of strategic priorities, including low costs, product quality, delivery reliability, short delivery cycle, flexibility to produce new product quickly, and flexibility to respond to volume changes. These can be achieved by using manufacturing technologies. Buffa (1984) argues that Japanese firms have gained the lead in many industries through closer attention to integrated manufacturing strategies with appropriate technologies. Burgess et al. (1998) suggest that firms need to take action to improve process performance through the adoption of process innovation. Cagliano and Spina (2000) explored the empirical basis of the strategic alignment of manufacturing strategy choices in accordance with the strategic priority and past experience in determining the selections of manufacturing improvement program. A complete strategic alignment is expected when the choice of the improvement programs is highly coherent with competitive priorities and the past experiences, thus the maximum pay-off could be achieved.

Although a number of studies have tried to investigate the technology-manufacturing strategy relationship, no clear pattern of the relationship between technology and its strategy has been found. Prior studies on the link between technology and manufacturing strategy tend to use the process approach which describes what technology should be adopted by companies having certain manufacturing strategies or competitive priorities. However, the way technology should align with manufacturing strategy remains unresolved. The above review of the literature shows the need to explore in greater depth the fit between manufacturing strategy and technology.

Research Framework and Hypothesis

Based on the above discussion, the theoretical framework for this research is diagrammed below.

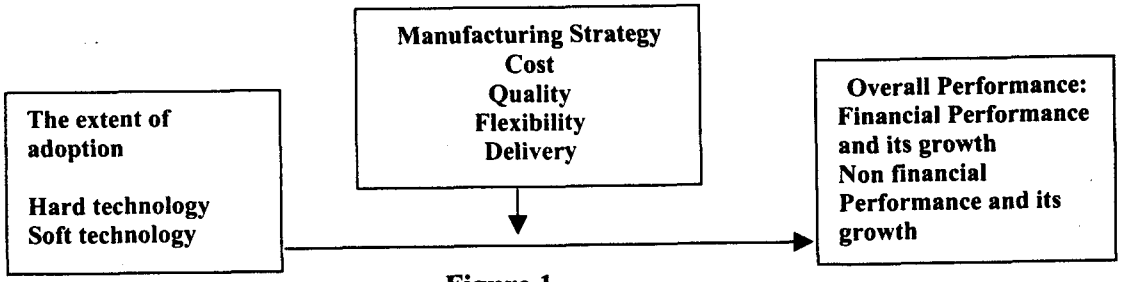


Figure 1
Research Framework

Within this framework two major hypotheses are proposed:

H1: There is a positive impact of level of technological adoption on firms' overall performance.

H2: The impact of technology on firms' overall performance is moderated by manufacturing strategy.

Research Method

Sample and Response Rate

For this study, a list of medium and large companies was obtained from the Directory of Manufacturing Industry, published by the Indonesian Statistic Center Bureau (Biro Pusat Statistik Indonesia, 2000). Data were collected through mailed questionnaires, which were addressed to the CEOs of medium and large manufacturing companies in Indonesia. The unit of analysis is organization and the sample was selected randomly from the directory. The sample selected were the manufacturing firms with more than 250 full time employees.

A total of 1000 questionnaires were sent to CEOs of large Indonesian manufacturing companies. Six companies were dropped from the target sample because four companies have moved to unknown addresses and the other two companies refused to participate. In addition, 47 incomplete responses cannot be used for this study. Finally, a total of 183 responses collected were used for the purpose of this study, an 18.41% response rate.

Respondents' Profile

The profile of the sample revealed an interesting spread of Indonesian large companies. The majority (60%) of the responding firms have less than 1000 full time employees with only 11.5% are very large, having in excess of 2500 full time employees. It is not surprising that about 90% of them have assets in excess of 25 million Rupiahs (1 USD equals to 9.850 Rupiahs). Most of them (80%) have been in existence for more than 10 years with only 8 companies (4.4%) being relatively new. Twenty-eight point four percent (28.4%) of the companies are in fabricated metal, machinery and automotive, and electronic industry, while 19.1% in food, beverage, and tobacco industry. The smallest (14.8%) group came from rattan, bamboo, furniture, and handicraft industries. In term of ownership, approximately 87% are Indonesian owned, while the remainders are either joint venture companies or totally foreign owned. However, locally owned companies do have some degree of alliances, only 47% indicated that they do not have any cooperative arrangement with foreign entities.

Variables and Measures

The variables of this study were measured using instruments derived from various sources.

Level of Technological Adoption

The two dimensions include hard technology and soft technology. Hard technology refers to a family of advanced manufacturing technologies and computer based technologies, which include 13 types of hard technology. Five point Likert type scales (1 = not adopted to 5 = very high) are used and in order to measure the level of adoption of hard technology, an instrument developed by Youseff (1993).

The level of sophistication, cost and complexity of the various hard technology varies. Thus to equate the one technology with another in coming up with a measure of extent of adoption of hard technology is inappropriate. For this study, we adopted the methodology used by Jantan, et al. (2001), where the extent of adoption is measured using the following formula:

$$\text{The extent of hard technology (AMT) adoption} = \frac{\Sigma\, i_j \times w_j}{\Sigma\, w_j}$$

Where:

i_j = Level of hard technology, where the value of i_j become 1 if the hard technology is not adopted at all and 5 if the hard technology is adopted at a very high level.

w_j = The importance (radicalness) index that was obtained from a panel expert. Where, w_j become 1 if the hard technology is considered very unimportant and 5 if the hard technology is considered very important.

To establish the degree of radicalness or importance of hard technology, a separate questionnaire was prepared and sent to experts (technical or production managers) from large manufacturing companies. These managers have had experience in working with hard technology systems. They are also considered as experts, and knowledgeable of the benefits of each type of hard technology and the difficulty in implementing the systems. The purpose of this part of the study is to determine the **weights** attached to each type of hard technology, in measuring the sophistication or extent of adoption of hard technology by the responding firms.

Soft technology refers to the system, which controls the technical processes within the organization such as TQM, JIT, TPM, MRP2, and Benchmarking. TQM measures are obtained and modified from Sohal and Terziovsky (2000). For the level of JIT adoption the components from Yasin, et al. (1997) as well as Sakakibara, et al. (1997) were adopted and modified based on the objective of this study. The level of MRP2 and TPM adoption is measured

with the instrument developed by Warnock (1996) and Tsang and Chan (2000), respectively. While the level of benchmarking adoption is measured based on the general benchmarking practices (Hinton, Francis, Holloway, 2000). A five-point Likert scale anchored by 1 (not practiced) to 5 (very high) is used to measure the level of soft technology adoption.

Manufacturing Strategy

Manufacturing strategy is defined as key decisions about the specific role to be played by manufacturing function in achieving competitive advantage (Dangayah and Deskmush, 2000), which includes cost, quality, flexibility, and delivery strategy. The instrument to measure manufacturing strategy is adopted from Badri, et al. (2000). Here, the respondents are asked to indicate their assessment to statements on a five point Likert's scale (1 = very unimportant to 5 = very important).

Performance

This study looks at performance from the perspective of overall performance by comparing each firm overall performance to the average in the industry. Overall performance covers financial performance and its growth as well as manufacturing performance and its growth.

These measures were subject to factor analyses to identify the structure of interrelationship (correlation) among a large number of variables (questionnaire responses in our case) by defining common underlying dimensions, known as factors. Factor analyses were conducted on the 13 questions of hard technology, 32 questions of soft technology, and 17 questions of manufacturing strategy. The factor analysis was conducted separately for extent of advanced manufacturing technologies and 32 organizational practices, two factors come up and named as hard technology (factor 1, Cronbach's alpha .9496) and soft technology (factor 2, Cronbach' alpha .9026). The results of factor analysis for manufacturing strategies emerged with four factors, the four factors are named accordingly, delivery strategy (factor 1, Cronbach's alpha .8813), quality strategy (factor 2, Cronbach's alpha .8344), flexibility strategy., and cost strategy. High Cronbach's alpha values of each of the derived factors indicated acceptable reliability level for further analyses (Nunnaly, 1978)

Finding and Discussion

The Impact of Technology on Performance

Table 1 presents the results of multiple regression analyses, which analyzed the impact of technology on firms' overall performance. Regarding the

impact of technology on overall performance we find that hard and soft technology have positive significant effects on overall performance. This finding indicates that companies can improve overall performance by adopting hard and soft technology. Adoption of hard technology is a vehicle to increase process and product quality, process and volume flexibility, as well as delivery reliability, thus improvement of manufacturing performance and its growth can be attained. This finding is in line with a large number of previous studies done by Youseff (1993), Baumounth & Schroeder (1997), Buthcher et. al (1999), Gordon and Sohal (2001).

This finding also shows that the effective implementation of soft technology leads to improvement in firm's overall performance. Implementation of this technology can reduce rework, scrap, and product defect. Soft technology also plays an important role in shortening process/product development time, and enhancing delivery capability, which leads to financial performance. This study appears in line with many previous studies about adoption of soft technology (Sohal & Terziovsky, 2000; Sakakibara, et al. 1997; Tsang and Chan, 2000; Hinton, et al. 2000). It shows that adoption of all types of soft technology will result in better performance than adoption of the specific technology. This is due complementary effect of all types of soft technology.

We also find that the impact of soft technology is greater than hard technology. Adoption of soft technology will give more benefits than hard technology. This is largely due to some factors that inhibit adoption and implementation of hard technology such as disruption during implementation, lack of integration of AMT with operation systems, skill deficiency, technical difficulties etc. These difficulties cause the impact of hard technology on manufacturing performance to be lower than that of soft technology.

Table 1
The Impact of technology on Performance

Independent Variables	Manufacturing Performance
R^2	.364
Adjusted R^2	.357
Sig. F	.000
Standardized Coefficients (β)	
Hard Technology (HT)	.243***
Soft technology (ST)	.431***
** significant at .01 * significant at .05	

The Moderating Impact Of Manufacturing Strategy

Hierarchical regression analysis is used to analyze the moderating impact of manufacturing strategy on the relationship between technology and performance.

Cost Strategy As The Moderator

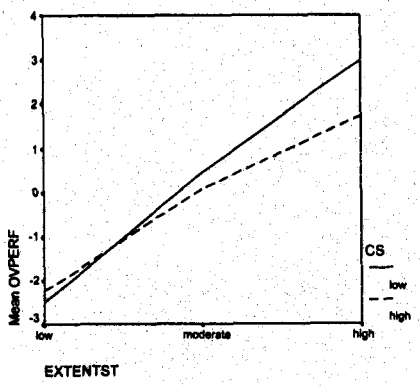
Table 2 shows the moderating role of cost strategy on the relationship between technology and overall performance. The addition of cost strategy and the interaction terms change the R^2 from 38.9 % to 42.6%. The R^2 change significantly increases and the F-change is significant at .01 level. Similarly, the significant standardized beta is found only in the interaction between soft technology and cost strategy.

Graph 1 shows the impact of cost strategy on the relationship between soft technology and the overall performance. In general, soft technology positively influences overall performance, but the impact of soft technology seems to be greater for the companies that emphasize less cost strategy. This is because amongst companies that practice cost strategy, investment in hard or soft technology is not a priority, as this will only increase cost of operations. Therefore, amongst firms that are willing to spend on technology, the impact of technology on performance will be the same irrespective of emphasis cost strategy. The finding is in line with that of Tan et al. (2000), who found that a strategy based on low cost correlates negatively with the use of product and process technology as a vehicle for performance improvement.

Table 2
The Moderating Effect of Cost Strategy on The Relationship Between Technology and Overall Performance

Variables	Step 1	Step 2	Step 3
	Standardized Beta		
HT	.259***	.261***	-.187
ST	.436***	.449***	1.553***
CS		-.050	.859***
HT x CS			.110
ST x CS			-1.658***
R^2	.387	.389	.426
R^2 change	.387	.002	.037
F change	56.446	.674	5.686
Sig. F change	.000	.413	.004
*** : significant at 0.01	** : significant at 0.05		

(Note: Step 1 refers to regression with the independent of hard technology (HT) and soft technology (ST); Step 2 refers to regression with the independent variables and the moderator (CS), whilst step 3 refers to the regression with the independent variables, the moderator and the interaction terms)



Graph 1
The Impact of Cost Strategy (CS) on the Relationship between Soft Technology (ST) and Overall Performance (OVPERF)

Quality Strategy as The Moderator

The moderating impact of quality strategy on the relationship between technology and the overall performance is given in Table 3. The addition of quality strategy in step 2 does not significantly change the F-ratio and the R^2, but the addition of interaction terms in step 3 changes the F-ratio and R^2 significantly (Sig. F change = .67 or sig. at .10). In this case, I find that quality strategy significantly moderates the effect of both hard and soft technology on overall performance.

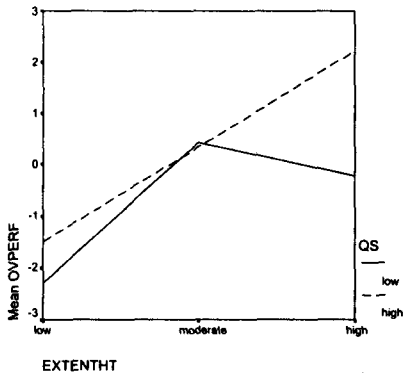
Table 3
The Moderating Effect of Quality Strategy on The Relationship Between Technology and Overall Performance

Variables	Step 1	Step 2	Step 3
	Standardized Beta		
HT	.259***	.259***	-.376
ST	.436***	.423***	1.163***
QS		.038	.500*
HT x QS			.794*
ST x QS			-1.259**
R^2	.387	.388	.407
R^2 change	.387	.001	.019
F change	56.446	.370	2.744
Sig. F change	.000	.544	.047

*** : significant at 0.01 ** : significant at 0.05 * : significant at 0.1

Graph 2 depicts the moderating role of quality strategy on the relationship between hard technology and overall performance. When the level of hard

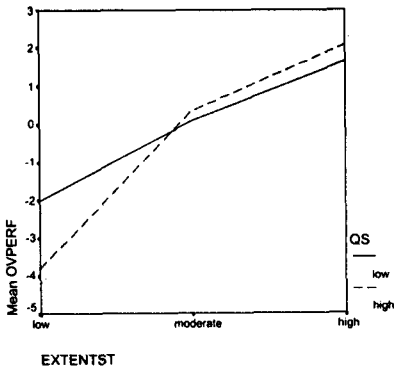
technology is low to moderate, the impact of hard technology on overall performance is positive for those companies that emphasize less quality strategy. Furthermore, when the extent of hard technology is moderate to high, the impact of hard technology on overall performance is positive for those companies with high emphasis on quality strategy, and negative for those companies with low emphasis on quality strategy. The highest performance is achieved when the priority on quality strategy is high while adopting high level of hard technology. It can be argued from the perspective that technology allows greater efficiency and productivity in the operation function, thus improving both manufacturing and financial performance. When coupled with greater focus on quality issues, product produced will be even more competitive and wastages through defects, reworks, and scrap will also be reduced, thus reducing cost of production. This finding corroborates Butcher et al. (1999), who found that the adoption of AMT (in term of CNC, CAD, LAN, and CIM) and greater emphasis on quality, flexibility and delivery reliability enhances companies' competitiveness through a range of improvement in production processes, quality control, increased capacity, flexibility, improved quality, reduced lead time, and increased internal rate of return.



Graph 2
The Impact of Quality Strategy (QS) on the Relationship between Hard Technology (HT) and Overall Performance (OVPERF)

The impact of quality strategy on the relationship between soft technology and overall performance is displayed in Graph 3. The distinct impact of soft technology on overall performance occurs when the level of soft technology is low to moderate, beyond which, the impact is the same. When the extent of soft technology is low to moderate, the impact of soft technology is greater for those companies that focus more on quality. The maximum performance is attained if the companies emphasize more on high quality strategy with adopting soft technology in highest level. Since soft technology includes management systems such as TQM, JIT, TPM etc., thus with high level of soft technology would already be emphasizing quality practices. Thus, high or low emphasis on quality

strategy will not influence the impact of technology on performance. However, when the level of soft technology adoption is low, focusing on quality strategy will help enhance the impact of technology by raising the performance level. This finding seems contradictory to that of Tan et al. (2000) who argued that companies with greater emphasis on quality strategy and coupled with quality management practices will result in greater impact on performance.



Graph 3
The Impact of Quality Strategy (QS) on the Relationship between Soft technology (ST) and Overall Performance (OVPERF)

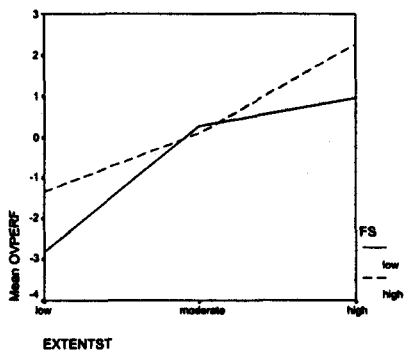
Flexibility Strategy as The Moderator

The moderating effect of flexibility strategy on the relationship between technology and overall performance is displayed in Table 4. It shows that the F-change from step 1 to 2 and from step 2 to 3 is significant at 5% level, respectively. The standardized beta for interaction terms between soft technology and flexibility appears significant at 5% level.

Table 4
The Moderating Effect of Flexibility Strategy on The Relationship Between Technology and Overall Performance

Variables	Step 1	Step 2	Step 3
	Standardized Beta		
HT	.259***	.235***	-.180
ST	.436***	.375***	1.198***
FS		.166**	.843***
HT x FS			.586
ST x FS			-1.501**
R^2	.387	.408	.428
R^2 change	.387	.021	.020
F change	56.446	6.430	3.070
Sig. F change	.000	.012	.049
*** : significant at 0.01	** : significant at 0.05		

Graph 4 shows that when the extent of soft technology is low to moderate, the impact of soft technology on the overall performance is greater for those companies that put less priority on flexibility strategy. However, when the extent of soft technology is moderate to high, the situation is reverse. Flexibility strategy focuses on meeting the change in customer demand in terms of volume and variety, which typically requires the support from advanced technologies. Thus, having advanced technology without flexibility strategy is a mismatch and this will be reflected in low performance in overall dimensions. This finding was supported by Gerwin (1993), Buthcher et al. (1999) and Beach et al. (2001).



Graph 4
The Impact of Flexibility Strategy (FS) on the Relationship between Soft Technology (ST) and Overall Performance (OVPERF)

Delivery Strategy as The Moderator

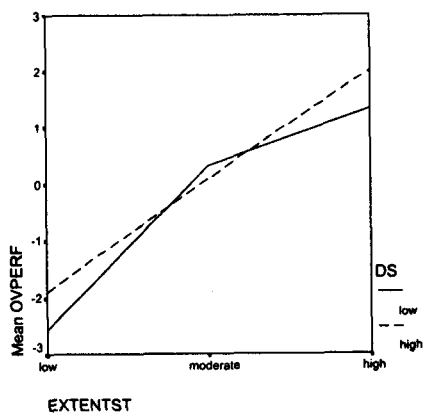
Table 5 summarizes the results of the regression analysis for testing the moderating role of delivery strategy on the impact of technology on overall performance. This table shows that the addition of delivery strategy in the second step is not significant but the change in F-ratio and R^2 is significant with the addition of the interaction terms. The significant beta coefficient for interaction between soft technology and delivery strategy indicates that the relationship between soft technology and the overall performance differs by the level of emphasis on delivery strategy. It is best seen through Graph 4.

Table 5
The Moderating Effect of Delivery Strategy on The Relationship Between Technology and Overall Performance

Variables	Step 1	Step 2	Step 3
	Standardized Beta		
HT	.259***	.256***	-.311
ST	.436***	.402***	1.287***
DS		.087	.673**
HT x DS			.718
ST x DS			-1.476***
R^2	.387	.387	.393
R^2 change	.387	.006	.024
F change	56.446	1.819	3.661
Sig. F change	.000	.179	.028

*** : significant at 0.01 ** : significant at 0.05 * : significant at 0.1

Graph 5 shows that when the extent of soft technology is low to moderate, the impact of soft technology on overall performance is greater for those companies that emphasize more on delivery strategy. However, in the event when the level soft technology is moderate to high, the situation is reverse. Delivery strategy emphasizes on responding to the customer's order by meeting delivery schedule as well as responding quickly to customer order. Delivery strategy can be operationalized by having soft technologies such as JIT, MRP2 TPM. It is aligning with Schroeder et al (2000) and Cagliano & Spina (2000) who assert that through alignment between technology and strategy high pay-off will be achieved.



Graph 5
The Impact of Delivery Strategy (DS) on the Relationship between Soft Technology (ST) and Overall Performance (OVPERF)

Conclusion

This study suggests that for the Indonesian manufacturing firms to survive and to grow, they need not only to improve its production capacities but also technological capabilities. The process of acquiring the technological capabilities and technological learning is not simple and effortless. Developing and maintaining these capabilities require both conscious effort by the organizations and also support from other institutions and government, in terms of partnership programmed and government policy that encourage technological development.

Indonesian manufacturing firms should consider adopting more of both types of technology. In the real world, the evidence shows that the effective adoption and mastery of technology requires not just the establishment of new production facilities, but also the knowledge and expertise for implementing technical change. The findings of this study also imply that the impact of technology on performance depends on the manufacturing strategy pursued. Aligning the resources is required to support manufacturing strategies in achieving better performance. Further, this study contributes significantly to the understanding of the technology–performance relationship in an environment of developing nations.

Although this study has presented a systematic approach to investigate the extent of technology adoption, however, it could not cover all the important issues in this field. Through this study, we still know little about the relationship between technology and performance. By doing this study it could be possible to observe and document variations of the extent of technological adoption, manufacturing strategy, environment variables and manufacturing performance interrelationship. Although this study used a sample of manufacturing companies in Indonesia, it would be interesting to replicate the study on manufacturing companies in other developing countries, which are known to have similar culture in adopting technology. Such a study will address the generalizability of the finding of this study.

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